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DRYING EAR CORN with UNHEATED AIR

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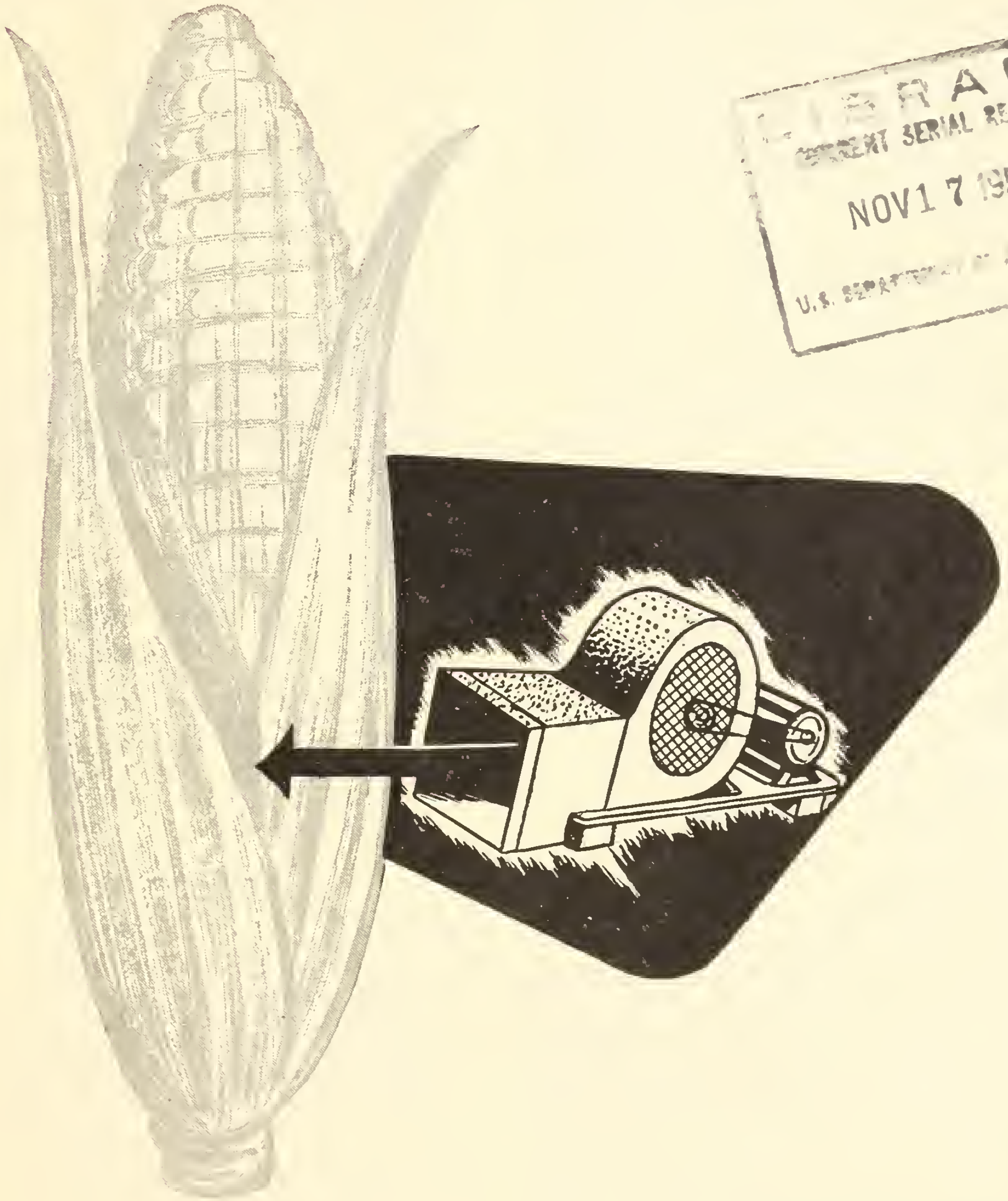

Leaflet No. 334

U. S. DEPARTMENT OF AGRICULTURE

GRAIN DRYING ON THE FARM

Grain drying by mechanical ventilation removes many of the hazards of harvesting and storing crops. Such drying is valuable to you not only when faced with the emergency handling of high-moisture crops, but also as part of your regular crop-management program. Controlled drying fits in with modern production, harvesting, and handling methods. It overcomes the problems arising from the use of grain combines and mechanical corn harvesters—equipment that gets the crops out of the field quickly but often dangerously wet. The availability of electric and gasoline-engine power and use of such power in driers of modern design makes mechanical ventilation possible.

Grain drying on the farm has the following advantages:

Corn can be—

1. Stored safely.
2. Marketed without a moisture discount.
3. Harvested early, thus taking advantage of good harvesting weather, reducing field losses from insects and bad weather, obtaining cleaner husking, lowering harvesting costs, and making possible fall plowing and seeding of wheat or cover crops.
4. Shelled and stored in tight bins in half the space required by ear corn, thus reducing storage losses caused by insects, rodents, and unfavorable weather.
5. Harvested with a picker-sheller.
6. Saved in wet years.

Small grains can be—

1. Stored safely.
2. Marketed without a moisture discount.
3. Harvested as soon as mature, thus reducing the chance of storm damage while waiting for the crop to dry in the field.
4. Harvested faster as combines can be operated earlier in the morning and later at night.
5. Combined directly without need for windrowing.
6. Saved even in wet harvesting weather, when, because of late seeding or poor growing weather, the crop must be harvested although it contains a high percentage of moisture.

The way to dry grain[1] is explained in this leaflet and the three others here listed, copies of which are available from your county agricultural agent, the Extension Service agricultural engineer at your State college, or from the Office of Information, the U. S. Department of Agriculture, Washington 25, D. C.

Leaflet 331, "Drying Shelled Corn and Small Grain with Heated Air," tells how this job can be done successfully on the farm.

Leaflet 332, "Drying Shelled Corn and Small Grain with Unheated Air," explains how unheated air can be used to reduce the moisture content of harvested grain to a point at which it can be stored safely on the farm or marketed without moisture discount.

Leaflet 333, "Drying Ear Corn with Heated Air," describes equipment needed and methods used in drying with heated air.

If drying crops with mechanical ventilation is new to you, the advantages and disadvantages listed below for both unheated- and heated-air drying may help when considering your drying set-up.

Heated-Air Drying

Advantages:	*Disadvantages:*
1. Can dry wettest grain.	1. Higher initial equipment cost.
2. Can dry regardless of weather conditions.	2. Expense for fuel.
3. Short drying time.	3. Some fire hazard.
4. High drying capacity per fan horsepower.	4. Considerable supervision required.

Unheated-Air Drying

Advantages:	*Disadvantages:*
1. No expense for fuel.	1. Dependent on weather conditions.
2. No fire hazard.	2. Slow drying rate; usually several weeks.
3. Lower initial equipment cost.	3. With drying prolonged, the grain may be damaged by mold growth.
4. Little supervision required.	

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[1] How to dry forage crops is described in Farmers' Bulletin 2028, "Drying Forage by Forced Ventilation."

Washington, D. C. Issued September 1952

Drying Ear Corn With Unheated Air

General Requirements

EAR CORN with a moisture content of up to 30 percent in the kernels can be dried successfully by mechanical ventilation with unheated air in the Corn Belt or in other areas with similar climate.

If weather conditions are normal after harvest, the corn will dry from 30 down to 20 percent moisture in 3 to 6 weeks of continuous ventilation. However, if the weather is especially humid after harvest, the corn may not dry down to 20 percent moisture before cold weather arrives. Under the latter condition ventilate the corn until it is frozen. Complete drying with additional ventilation as the weather warms up in the spring.

Follow this procedure for drying with unheated air:

1. Harvest before October 15. This will enable you to take advantage of good drying weather as well as good harvesting weather.
2. Make sure that corn to be dried is reasonably free of husks, silks, and shelled corn. Foreign material that cannot be removed should be distributed uniformly through the batch.
3. Provide an adequate quantity of drying air in an even flow through the batch. See table 1 for recommended rates of air flow.

Cribs, Bins, and Air Ducts

Various types of cribs, bins, and air-duct arrangements for use in drying and storing ear corn are illustrated in figures 1 through 13. All illustrations show air being forced through the corn, but the unheated air can be drawn through the corn if desired.

You can use canvas or reinforced paper, fastened with wooden strips about 2 feet apart, to enclose partly a crib of the type shown in figure 1. Canvas, as shown in figure 1, or reinforced paper over a light wooden frame makes a suitable air duct outside and along the front of the crib. You can attach the canvas or paper on the crib after it has been filled. After mechanical ventilation is complete, you can easily remove the wall covering and duct to permit normal ventilation of the corn.

A slatted or wire air duct has been installed on the inside of the crib shown in figure 2. You can use canvas or reinforced paper to enclose the crib in the same manner as for the crib shown in figure 1. The only difference is that the back of the crib in figure 2 has also been covered. The diagram at top, left, of figure 2 shows the duct placed over a shelling trench. The trench must be airtight at the end opposite the fan.

You can prepare the large rectangular double crib shown in figure 3 for drying ear corn with unheated air by closing the driveway doors and sealing them with reinforced paper. Or, you can place airtight bulkheads at each end of the driveway. If the end walls are not tight, cover them (shown as *a* in fig. 3) or cover the driveway walls back 6 to 8 feet from the crib ends (*b*). Covering the end walls is better.

If back of overhead bin-wall studs are slatted, remove the slats or block the spaces to prevent a short circuit of air. However, if height of overhead bin wall in high cribs is greater than the crib width, leave some slats at the bottom of the bin-wall studs (shown as *c* in fig. 3).

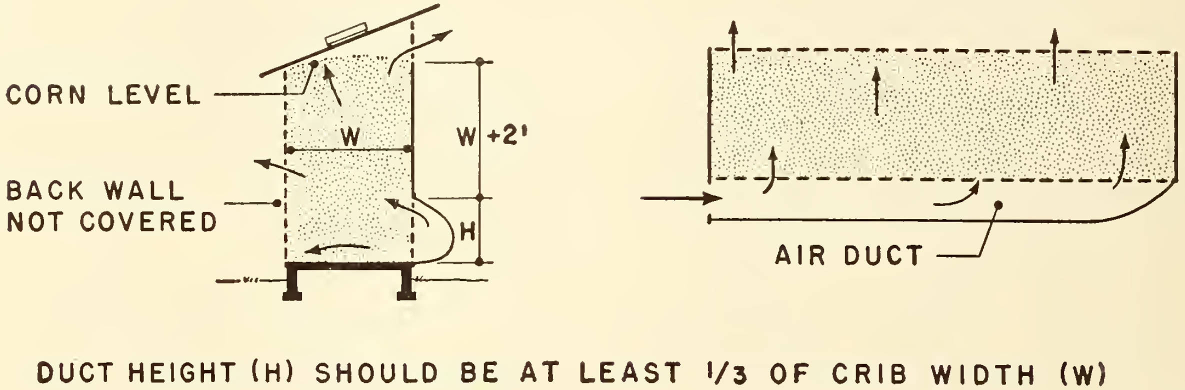
If you fill this type of crib only part way, and the height of corn above the bin floor is not 2 or 3 feet greater than the width of the crib, cover the upper part of the driveway wall (shown as *d* in fig. 3) to provide an even flow of air through the corn.

Prepared by the Division of Farm Buildings and Rural Housing, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration. The research on which this publication is based was in cooperation with the agricultural experiment stations of Illinois, Iowa, and Indiana and with the Production and Marketing Administration, United States Department of Agriculture. Helpful suggestions were also received from agricultural engineers of other experiment stations, from Rural Electrification Administration, United States Department of Agriculture, and from the manufacturers of crop driers and fans.

Narrow alleyways in cribs of the type shown in figure 4 are used as air ducts and for unloading. The end walls of this type of crib must be tight, but use slats in the side walls and in the walls of the alleyway. This will permit both mechanical and natural ventilation.

Use of a slatted, removable air duct down the center of the driveway of the double crib as shown in figure 5 will enable you to fill ear corn into both cribs and the driveway area. Set the duct down the center on the driveway floor.

Installation of a duct or tunnel system will enable you to dry and store ear corn in a prefabricated general-purpose building of the type shown in figure 6. General-purpose buildings are made of either metal or wood. Some have straight sides instead of arched ribs. You must have a slatted wall just inside the wall of the structure so that the drying air may pass through the corn to the side walls of the bin. Place a slatted sectional air duct down the center of the floor.



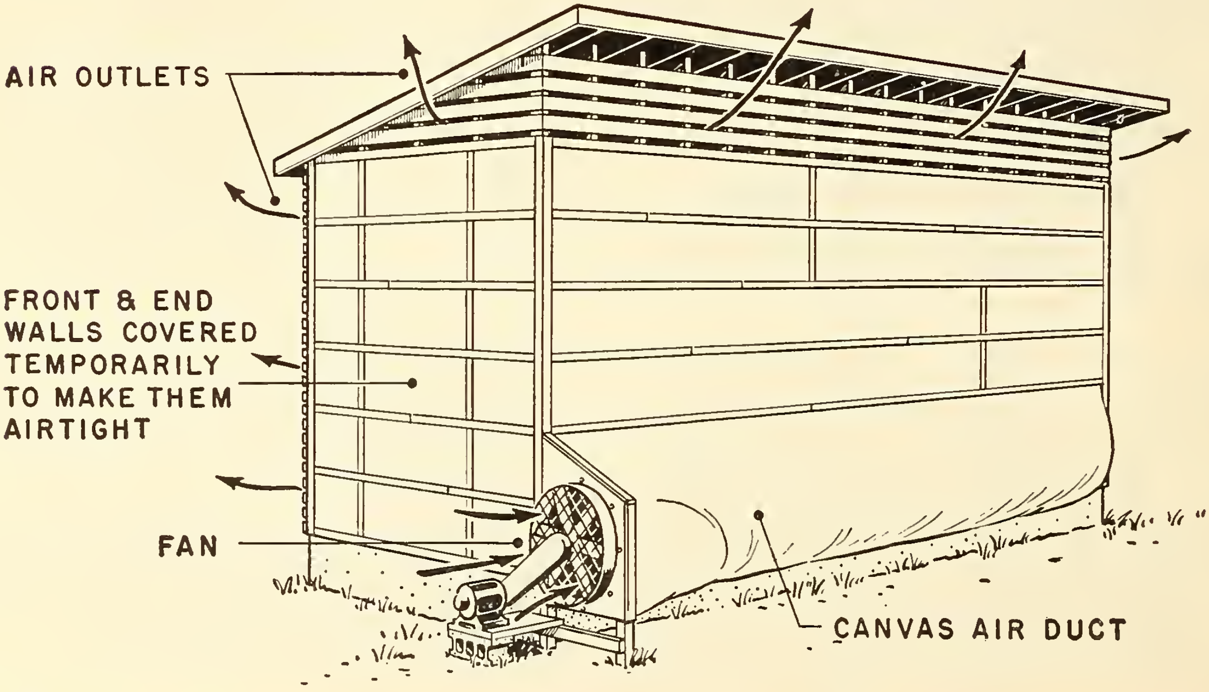


Figure 1.—*Single crib partially enclosed with canvas or reinforced paper. Air duct of canvas outside the crib.*

You can use either snow fencing or welded wire to build a temporary circular crib of the type shown in figure 7. You must install the air entrance and main ducts before the crib is filled.

The prefabricated high round crib shown in figure 8 has perforated walls and a vertical, slatted main air duct which makes it readily adaptable to mechanical drying. If you fill a crib of this type only partially, block the main air duct for more efficient drying. Place the blocking below the surface of the corn at a depth that is determined by adding 2 feet to the distance from duct to wall. Seal the walls of the duct above the blocking to prevent a short circuit of the drying air. Such materials as heavy pasteboard, plywood, or reinforced paper can be used for sealing. If you decide to leave the crib only partly filled, you can use corn to seal the duct area above the blocking.

If you have an oval-type masonry crib as shown in figure 9, a fairly uniform distribution of air is possible with the arrangement illustrated. Uniform distribution of air flow in this type of crib is difficult to obtain unless some special arrangement is provided for it. The vertical air duct shown inside the crib will help to provide a uniform air flow to the side walls and will also improve air circulation through the corn in the upper part of the crib, near the overhead grain-bin walls.

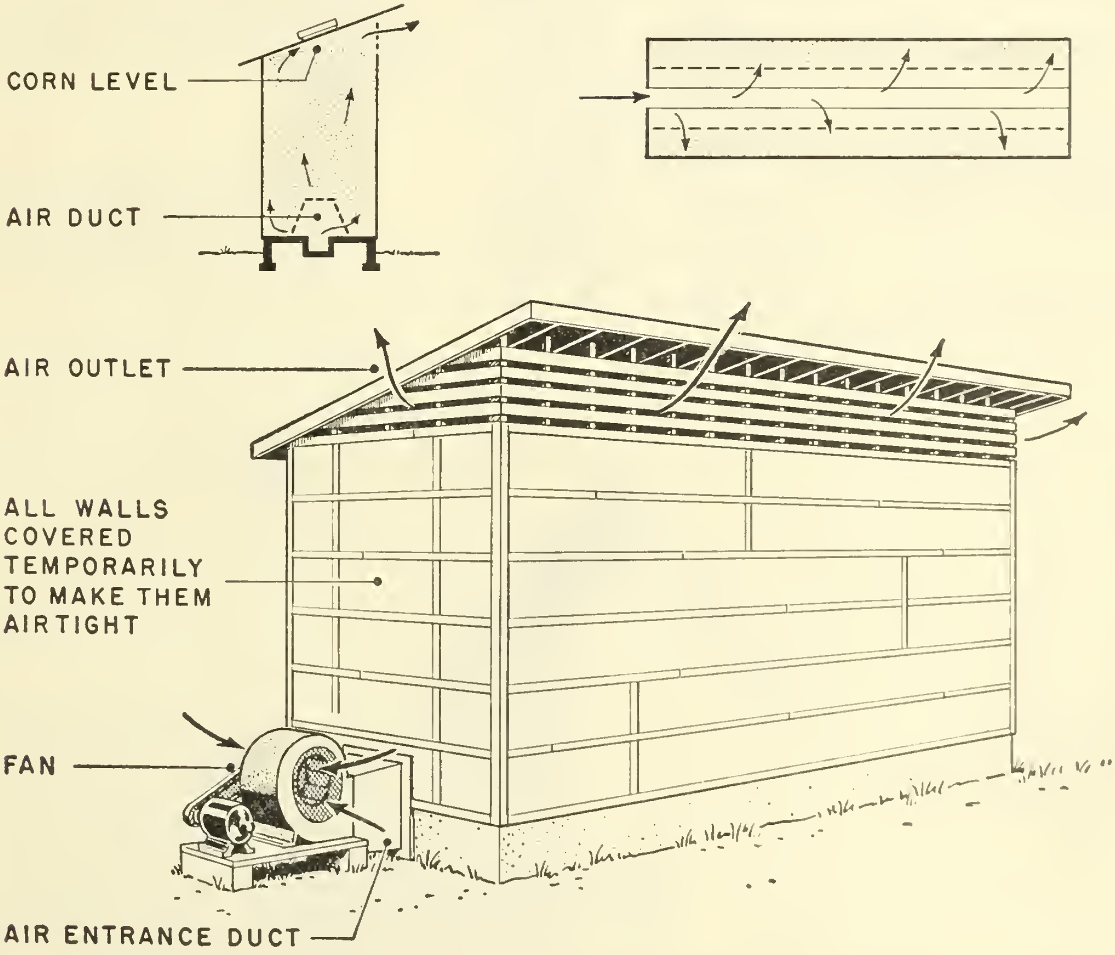


Figure 2.—*Air duct on inside of single crib. The crib is enclosed with canvas or reinforced paper.*

A duct system that can be used when drying ear corn in rectangular or circular bins is shown in figure 10. For uniform air distribution the ear corn depth should be at least 6 feet. The main duct, shown in figure 10 in the middle of the bin, could be located along one side, either inside or outside of the bin. Build the lateral ducts in about 4- to 6-foot sections, so that you can remove them easily while emptying the bin. Details on construction of the duct system are shown in figure 11.

Construction details of a duct system that is suitable for use in several types of bins, as just described, are shown in figure 11. You can make the main duct rectangular, rounded, or triangular. The main duct should be larger throughout than the fan outlet, and it should be free of sharp turns. Provide 1 square foot of cross-section area for each 1,000 cubic feet per minute (c. f. m.) of air flow from the drier. For example: If the drier delivers air at the rate of 9,000 c. f. m., provide a cross-section area of at least 9 square feet for the main duct. The duct could be 3 feet square. Provide small

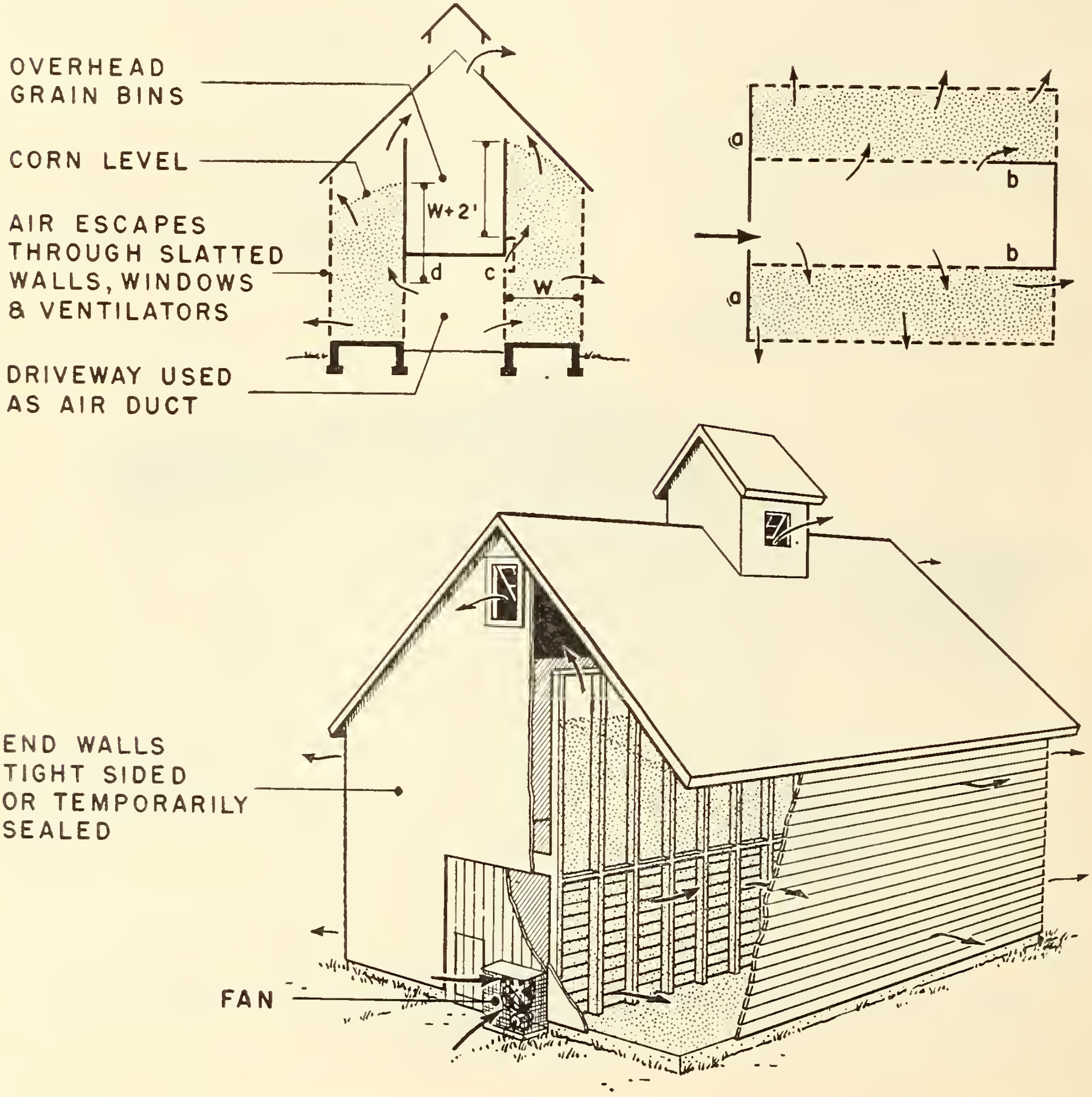

OVERHEAD GRAIN BINS
CORN LEVEL
AIR ESCAPES THROUGH SLATTED WALLS, WINDOWS & VENTILATORS
W+2'
d
c
W
DRIVEWAY USED AS AIR DUCT
a
b
b
a
END WALLS TIGHT SIDED OR TEMPORARILY SEALED
FAN

Figure 3.—*Large rectangular double crib prepared for drying ear corn and equipped with fan to supply unheated air.*

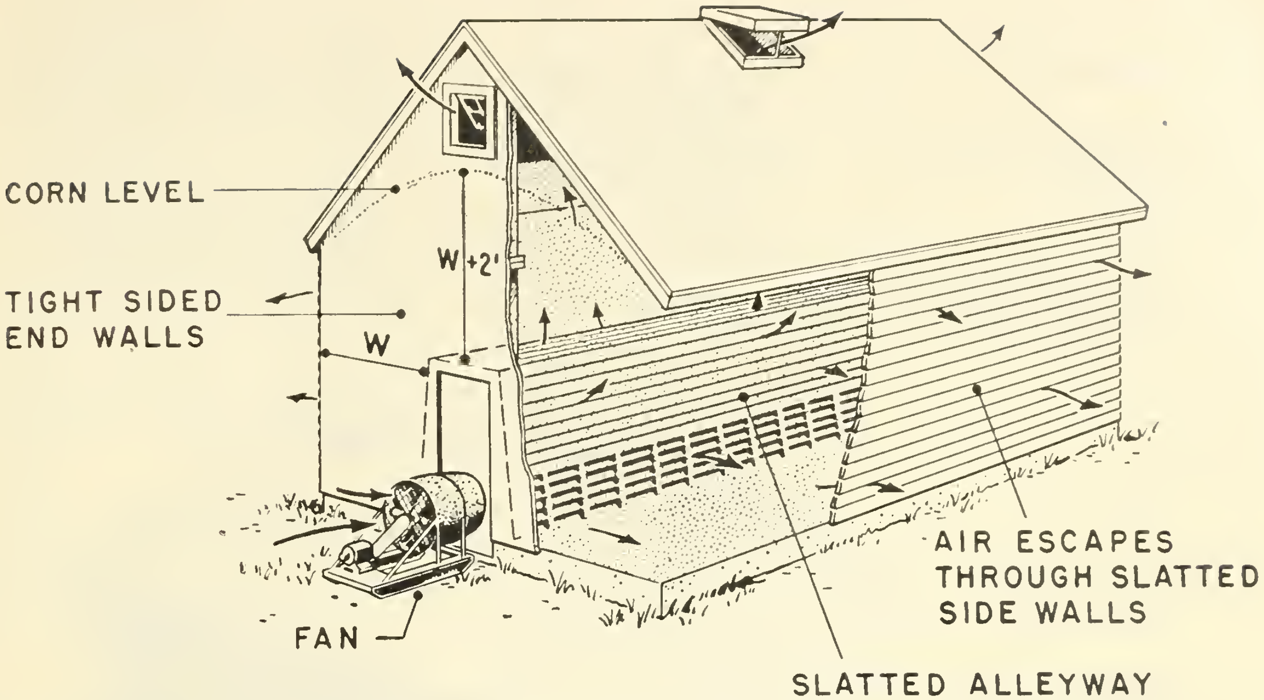


Figure 4.—*Wide crib with 4-foot alleyway. The alleyway is used as an air duct and also for unloading the crib.*

screened openings along the top of the duct so that air may pass upward to dry the corn above.

Space lateral ducts so that the distance between them, center to center, is not more than one-half the depth of the ear corn to be dried. If all the lateral ducts are of the same length, you can compute the cross-section area required for each by dividing the cross-section area of the main duct by the number of laterals. For example: With six laterals of the same length and a main duct cross-section area of 9 square feet, divide 9 by 6. Thus, the cross-section area for each lateral should be about 1½ square feet. If such lateral ducts are built in rectangular form, two 1- by 10-inch boards, sufficiently braced, for the top, and two 1- by 12-inch boards, one for each side, would be satisfactory. Laterals also may be triangular or rounded in shape.

The width of each lateral should be at least twice the height of its bottom edge above the floor. This height above the floor should be about 7 and 10 inches, respectively, for laterals spaced 4 and 6 feet apart from center to center.

In any case the total area for air passage under all the lateral ducts (height from floor to bottom of lateral times length of both sides and one end of each lateral) should be equal to at least one-fourth of the area of the bin floor. If you use perforated metal sheets to make the laterals, and the sheets have uniformly spaced perforations equaling at least 10 percent of their total area, you may set the laterals directly on the bin floor.

The false floor of the circular metal bin shown in figure 12 is of perforated metal. Cover the floor evenly with ear corn before starting the fan. Ear corn can be dried at depths up to 16 feet or even deeper. If a conveyor is to be used beneath the perforated floor, place this floor at least 16 inches above the permanent floor or ground. Support the false floor on wood framing and concrete blocks or on other suitable supports. Lay the blocks so that air can circulate through the openings. Provide one block for each 40 bushels (70 pounds per bushel) of ear corn or 50 bushels of grain that can be placed in the bin. Perforations should amount to at least 7 percent of the total area of the floor. You will find it best to mount the perforated floor in removable sections so that the space under the false floor can be cleaned easily. Several companies make the perforated metal sheets that can be used for false floors. You can get plans for installing the floors from these companies. Perforated metal floors can also be used in other types of bins.

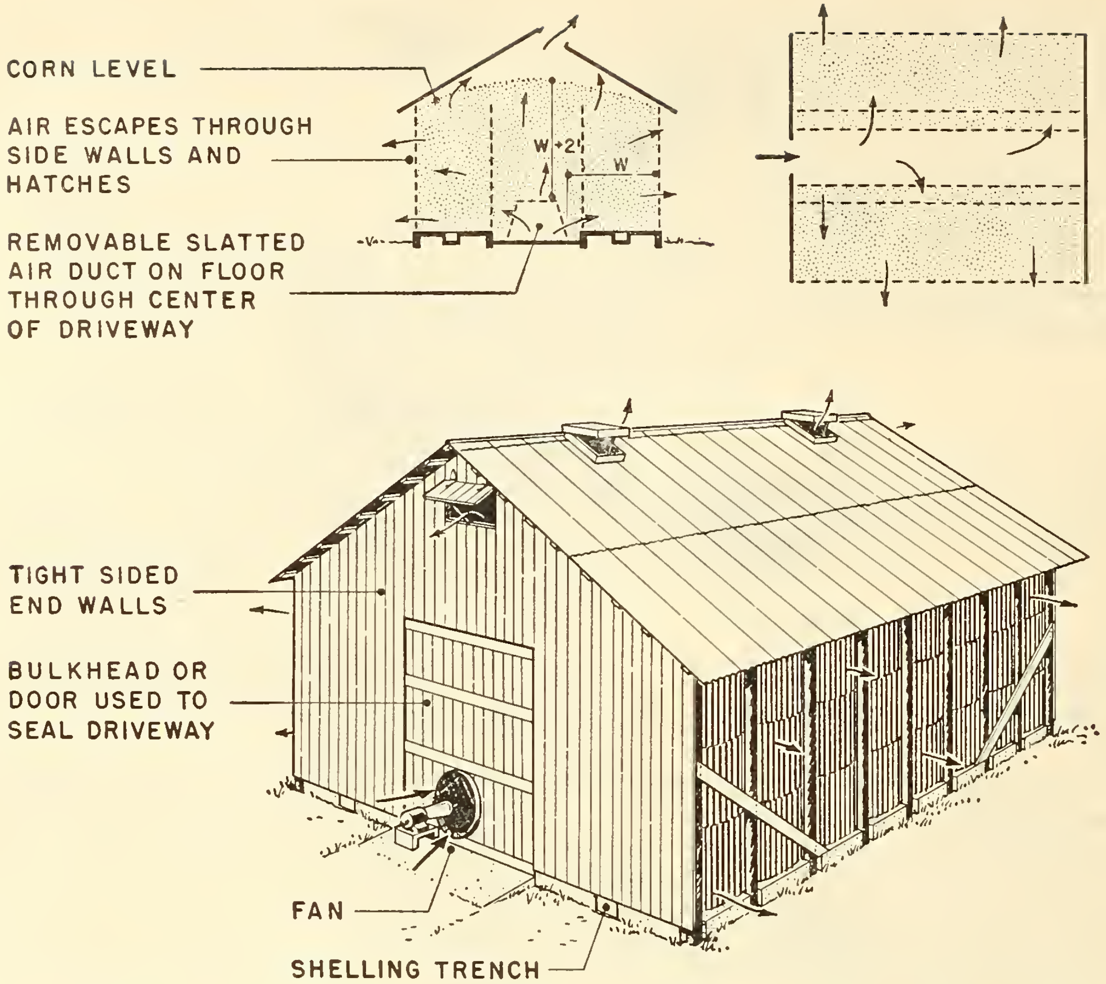

CORN LEVEL
AIR ESCAPES THROUGH SIDE WALLS AND HATCHES
REMOVABLE SLATTED AIR DUCT ON FLOOR THROUGH CENTER OF DRIVEWAY
W+2'
W
TIGHT SIDED END WALLS
BULKHEAD OR DOOR USED TO SEAL DRIVEWAY
FAN
SHELLING TRENCH

Figure 5.—*Double crib without overhead bins, adapted for mechanical drying of ear corn.*

Hardware cloth can be used instead of perforated metal sheets as material for false floors in drying bins, as shown in figure 13. Lay the concrete blocks so that air will circulate through them. Rows of blocks laid 4½ feet apart will support ear corn to a depth of up to 16 feet or of shelled corn or grain up to 9 feet.

If the drying bin is to be used for ear corn only, 1- by 6-inch slats spaced ¾ inch apart and laid flat on stringers across rows of blocks may be substituted for the 2 by 4's and hardware cloth shown in figure 13. For this slatted floor to support a 16-foot depth of ear corn, the rows of blocks should be only 2 feet apart and the blocks not more than 18 inches apart within rows. Use the 2 by 8 stringers shown in figure 13.

To prevent air loss, use canvas or reinforced paper as temporary coverings for slatted bin walls, as shown in figures 1, 2, and 3. The coverings can be held in place by wooden strips about 2 feet apart and at right angles to the air flow. Also place strips over joints or laps. Shelling trenches should be covered with reinforced paper if not used as main ducts.

Bins with tight walls (figs. 6, 10, and 12) do not require temporary wall covering, they keep snow out, and are easier to make ratproof. Cribs with tight end walls or vertical central ducts also require no temporary covering (figs. 3, 4, 5, 7, and 8).

Fill bins and cribs so that at the start of drying the height of corn above a slatted air duct is about 2 feet greater than the distance from the duct to the perforated or slatted wall. (Shown as W+2 in figs. 4 to 9.) Where air is to enter or leave the main duct through a side wall, the height of corn or covered wall above the top of the air inlet should be 2 feet greater than the crib width (figs. 1 and 3). Corn settles from 1 to 3 feet as it dries, the amount of settling depending on initial moisture and initial depth of the corn. Allowance must be made for this, or too much of the drying air will pass through the corn at the shallower depth. With tight walls, settling does not affect uniform air flow if the perforated floor or ducts are covered with corn to even depth.

Cross ties in cribs prepared as in figures 1, 3, and 4 interfere with proper air distribution. As the corn dries and settles, a channel is formed under each cross tie. These channels permit air to escape from the crib without going through the corn above the cross ties. To reduce this loss, cover a strip of the outside wall 2 to 4 feet wide at the level where the cross ties join the wall.

Where air enters or leaves the corn through a slatted side or top of the main air duct or through a perforated or slatted floor (fig. 1 through fig. 9), the slatted area should equal at least one-third of the total floor area.

In some cases it may be necessary or desirable to ventilate corn in a partly filled crib or bin. With a perforated floor or floor ducts, you may start drying any time after the duct surfaces are covered to a uniform depth. With the other arrangements shown, some modification of ducts or placement of corn may be necessary when the crib is only partly filled. In planning a drying set-up under such conditions, remember that the drying air should travel about the same distance through the corn in all parts of the crib.

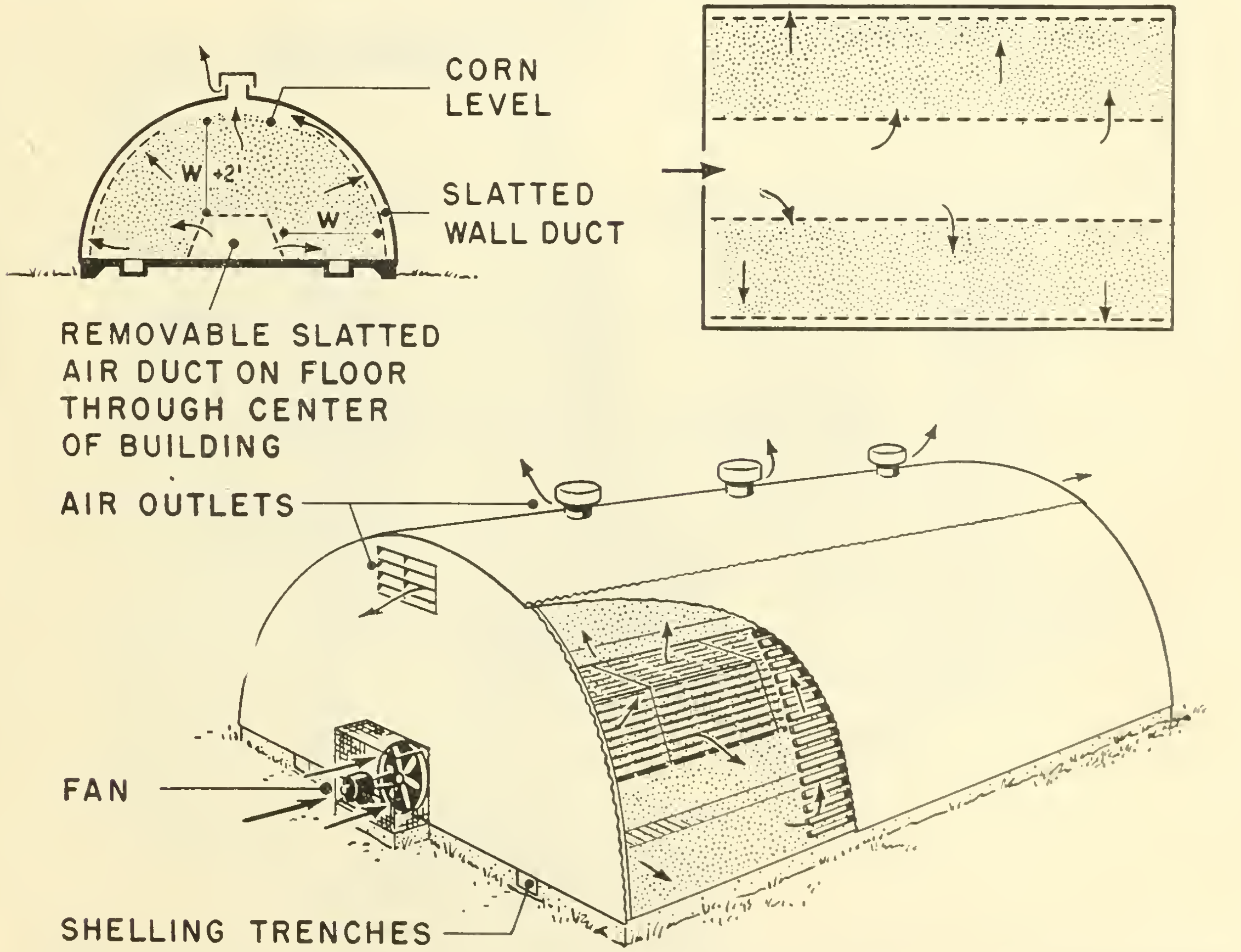


Figure 6.—*General-purpose building equipped with air duct and fan unit for drying ear corn with unheated air.*

Harvesting and Cribbing the Corn

Shelled corn, husks, and silks mixed with the ears tend to fill the spaces between ears and interfere with air distribution. Air will bypass and fail to dry ear corn where these materials accumulate. To avoid this, husk the corn as clean as possible. Also, use a screen in the elevator; this will take out some of the foreign material. Unless the elevator drops the corn on a spreading device in the crib, move the elevator spout frequently, directing it so that any shelled corn will be deposited near the outside wall rather than in the middle of the crib.

Air-Flow Requirements

A minimum air flow of 5 c. f. m. per bushel of ear corn is recommended when the kernel moisture before drying is 30 percent, and 3 c. f. m. per bushel when the kernel moisture before drying is 25 percent (see table 1). Increasing the rate of air flow will result in faster drying, but the drying rates will not increase in direct proportion to the rate of air flow: that is, doubling the air flow does not double the rate of drying. For this reason, the cost of power for drying a batch of corn will be the least when the minimum effective rate of air flow is used. Too low a rate of air flow may permit spoilage of corn from mold or heating.

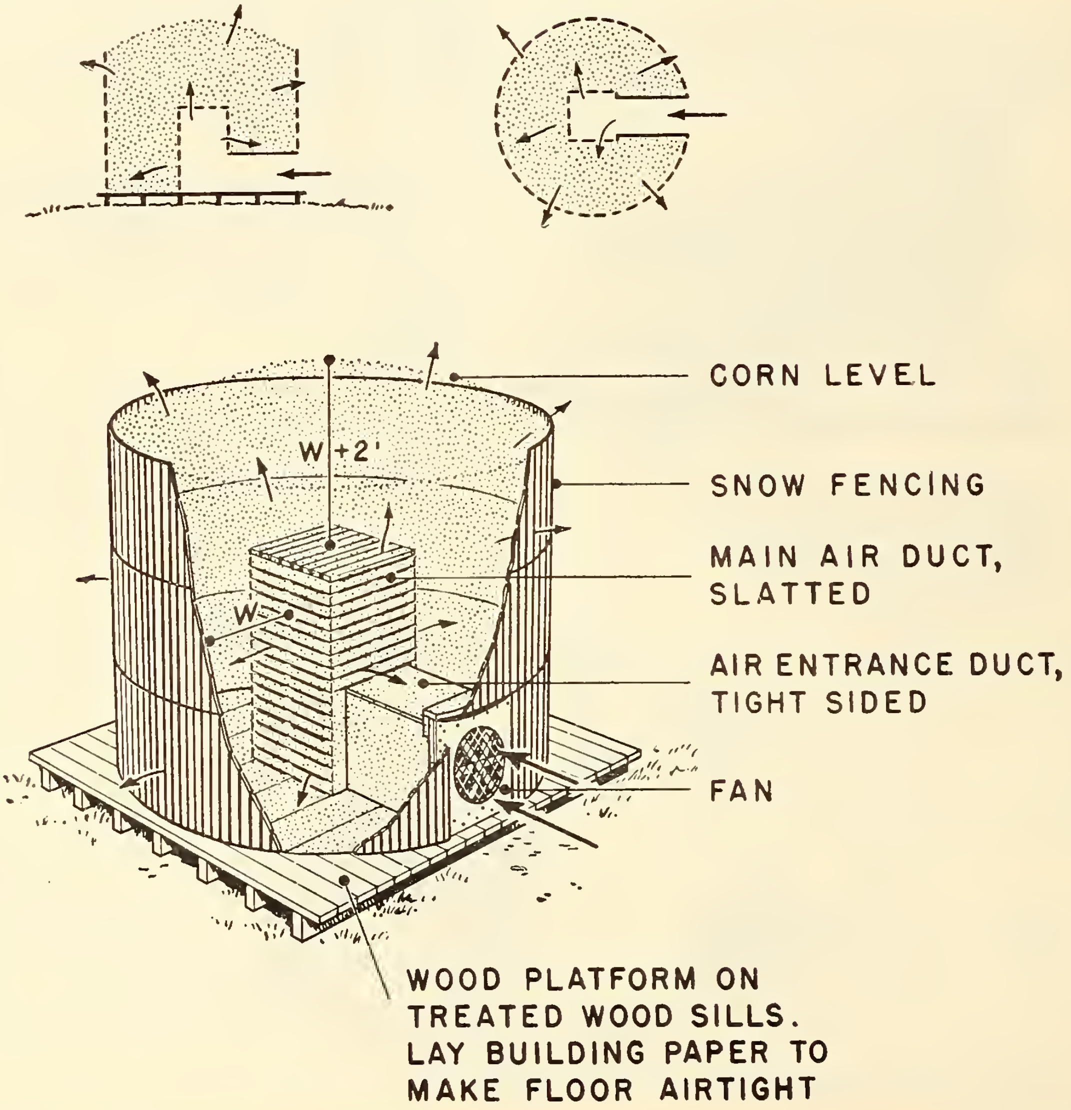

CORN LEVEL
SNOW FENCING
MAIN AIR DUCT, SLATTED
AIR ENTRANCE DUCT, TIGHT SIDED
FAN
W+2'
W
WOOD PLATFORM ON TREATED WOOD SILLS. LAY BUILDING PAPER TO MAKE FLOOR AIRTIGHT

Figure 7.—*An inexpensive, easily built crib for the mechanical drying of ear corn.*

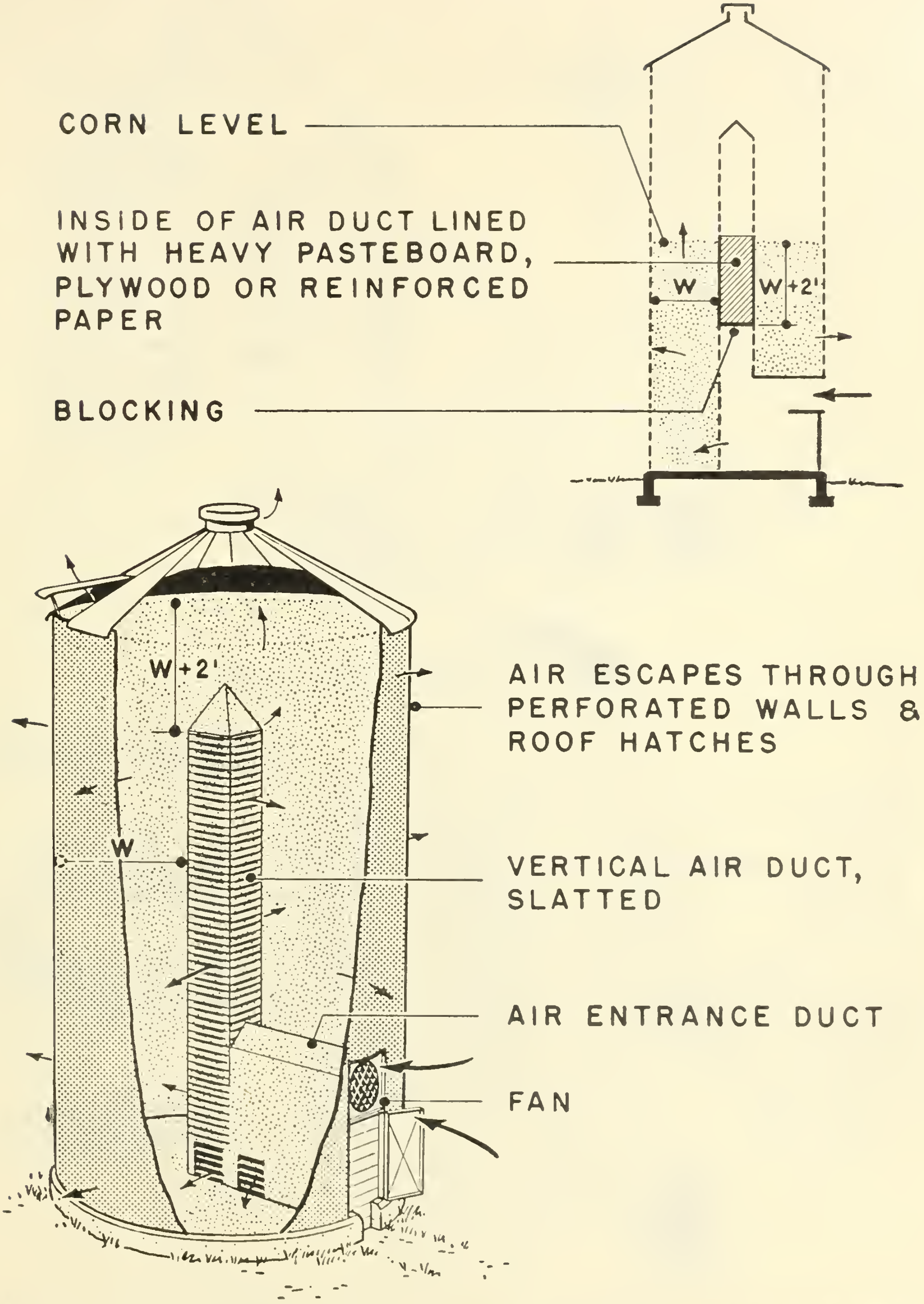

CORN LEVEL
INSIDE OF AIR DUCT LINED WITH HEAVY PASTEBOARD, PLYWOOD OR REINFORCED PAPER
BLOCKING
W
W+2'
AIR ESCAPES THROUGH PERFORATED WALLS & ROOF HATCHES
VERTICAL AIR DUCT, SLATTED
AIR ENTRANCE DUCT
FAN
W+2'
W

Figure 8.—*High round crib with perforated walls. The main air duct in the center of the crib is vertical and slatted.*

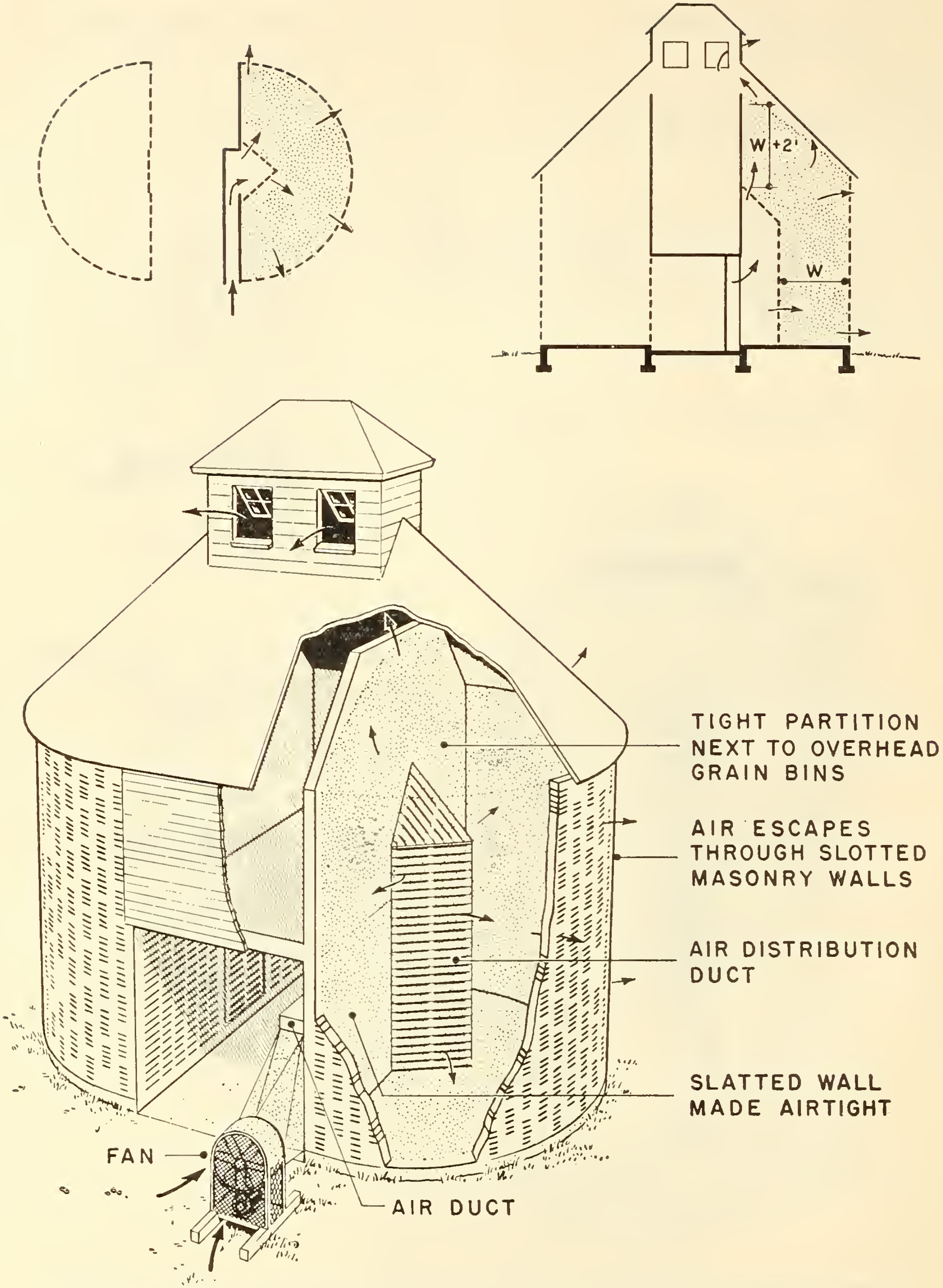

W+2'
W
TIGHT PARTITION NEXT TO OVERHEAD GRAIN BINS
AIR ESCAPES THROUGH SLOTTED MASONRY WALLS
AIR DISTRIBUTION DUCT
SLATTED WALL MADE AIRTIGHT
FAN
AIR DUCT

Figure 9.—*Suggested arrangement of oval-type masonry crib for the mechanical drying of ear corn.*

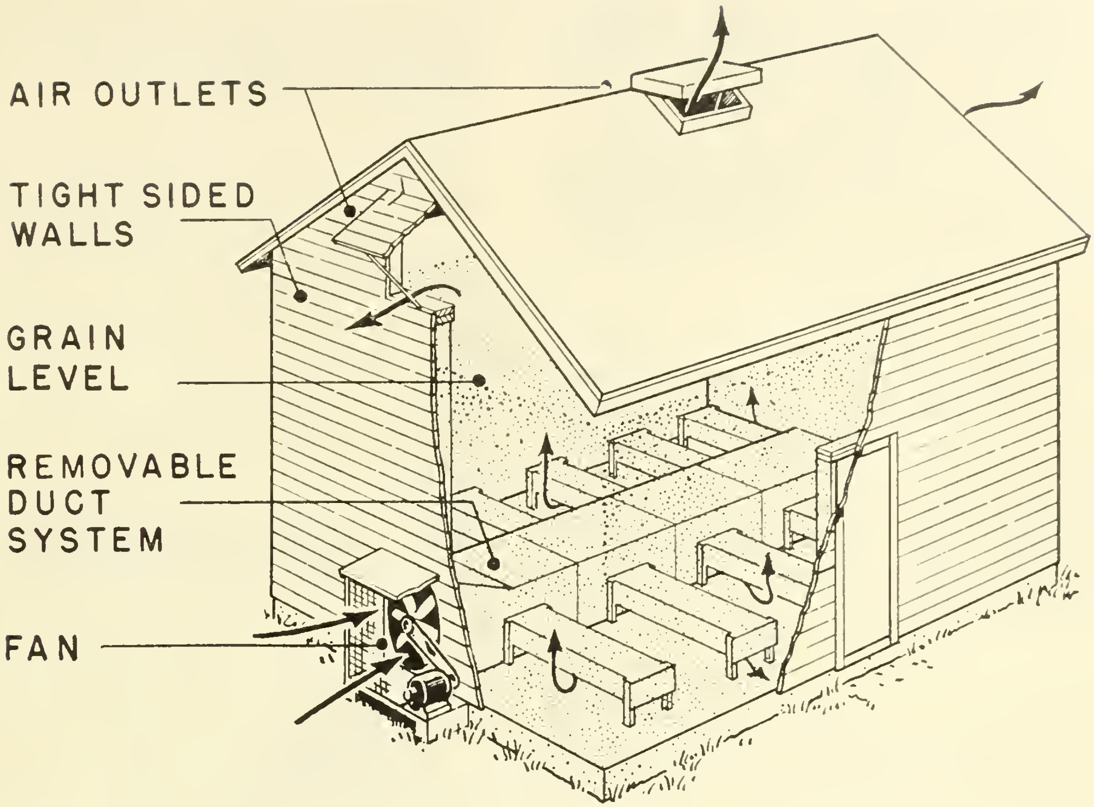


Figure 10.—*Rectangular bin with duct system.*

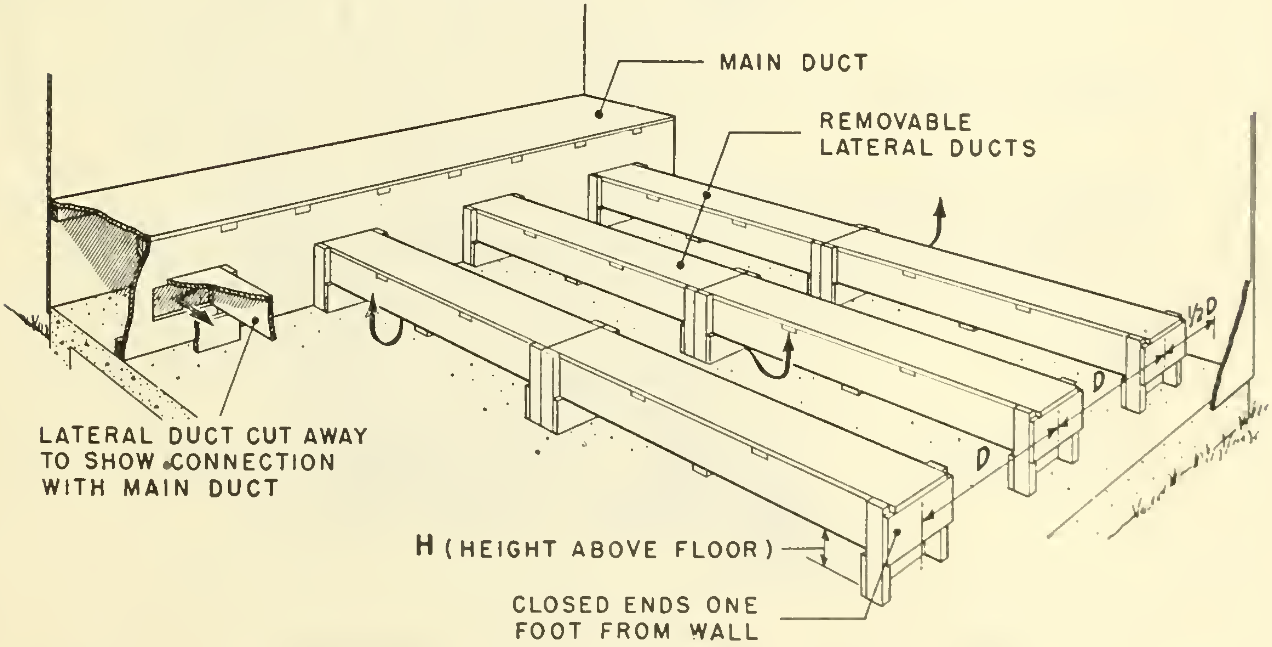

MAIN DUCT
REMOVABLE LATERAL DUCTS
½D
D
D
LATERAL DUCT CUT AWAY TO SHOW CONNECTION WITH MAIN DUCT
H (HEIGHT ABOVE FLOOR)
CLOSED ENDS ONE FOOT FROM WALL

Figure 11.—*Details of duct system for drying bin.*

Equip your crib or bin with a fan that will supply at least 5 c. f. m. of air per bushel when the crib is full. For example, if the crib capacity is 1,500 bushels, the fan capacity should be 1,500×5=7,500 c. f. m. In an emergency, when corn must be harvested at a moisture content greater than 30 percent, a higher rate of air flow per bushel can be obtained by filling bins or cribs only partially.

Equipment

The equipment required for drying is a drying structure, a suitable fan, and a power unit, preferably an electric motor. The greatest number of bushels of corn that should be dried per fan horsepower are shown in table 1. If larger quantities of corn are dried per horsepower, there will be more risk of unsatisfactory drying. If smaller quantities of corn are dried, the cost per bushel will be increased.

TABLE 1.—*Recommended minimum rates of air flow and maximum number of bushels of ear corn that should be dried per fan horsepower by mechanical ventilation with unheated air*

Kernel moisture content (percent)	Recommended minimum air flow rate per bushel	Maximum quantity of ear corn that can be dried per fan horsepower [1]
	C. f. m.	*Bushels*
30	5	800
25	3	1,300

[1] Calculated on basis of a static pressure of ¾-inch water gage and a fan air delivery rate of 4,000 cubic feet per minute per horsepower.

As shown in table 1, the fan should deliver 4,000 c. f. m. of air per horsepower against a static pressure

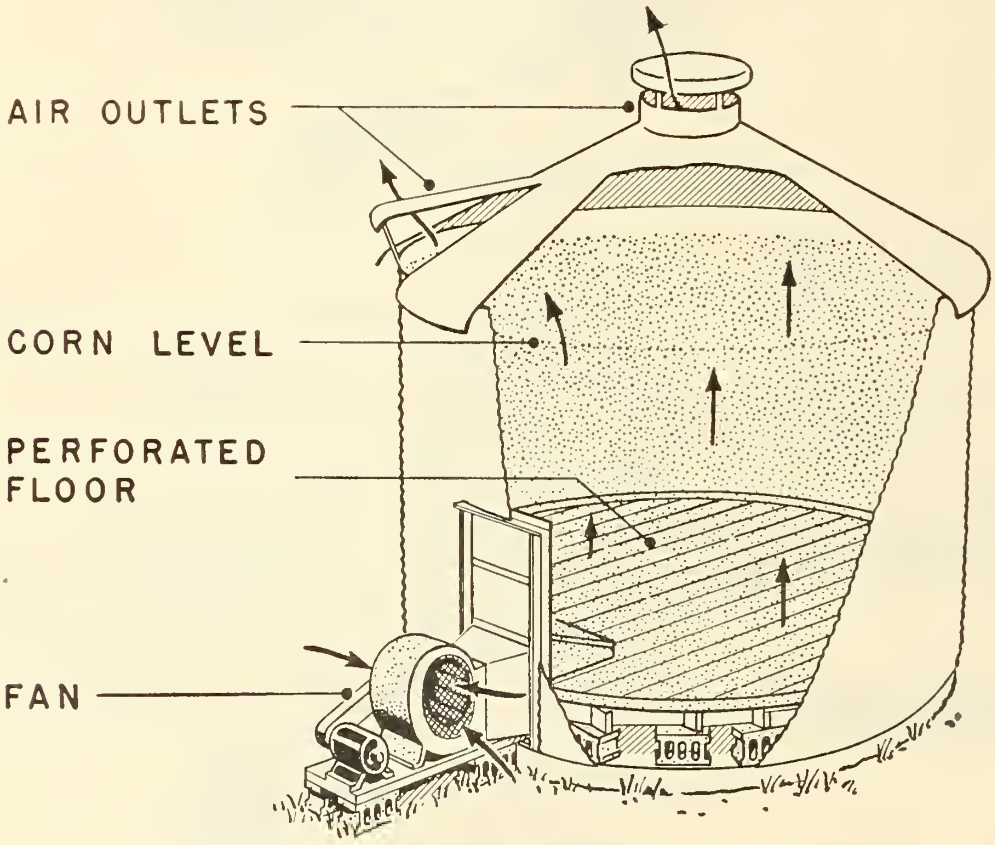


Figure 12.—*Circular metal bin with false floor of perforated metal.*

of ¾-inch water gage. As it is not practical to test fan performance on a farm job, you will have to rely on the manufacturer's rating of the fan. You would be unwise to buy any fan lacking a reliable rating, or one that has no pressure listings with the cubic-feet-per-minute ratings. Wind stackers, ensilage or hay blowers, or home or barn ventilating fans are not suitable for corn drying.

Where electric power is not available, gasoline-engine power can be used to drive the fan. The main objection to gasoline-engine power is that it calls for more labor of attendance and maintenance.

Since ventilation usually continues for several weeks, one fan unit will dry only one crib of corn each year.

Use of the Same Equipment for Drying Ear Corn and Forage Crops

Fans for drying ear corn are also suitable for drying forage crops, because the static pressure encountered in drying each is about the same. For economical operation, the quantities of each crop to be dried should require about the same total air delivery rate from the fan. For example, a 3-horsepower fan suitable for drying about 2,400 bushels of ear corn will dry from 12 to 20 tons of hay per batch. Such fans are also suitable for drying shelled corn and small grains by adjusting the quantity and depth of grain to be dried. (See Leaflet 332. Drying Shelled Corn and Small Grain with Unheated Air.)

Operation

Begin ventilation as soon as all of the corn to be dried at one time is in the bin or crib. Continuous day-and-night operation is generally recommended except in case of rain or fog. Corn containing 25 percent or more of moisture is so wet that it will not gain moisture when ventilated with very damp air, unless the corn is colder than the air. High-moisture corn will dry during night ventilation in ordinary weather. A small saving in power cost can be made by intermittent (daytime only) operation, but it will take more days—but less actual running time—to get the corn dry than with continuous operation. If you want to ventilate the corn during the daytime only, turn the fan on at about 10 and keep it running until the corn has cooled in the evening, or about 9 or 10 o'clock.

Corn at the surface where the air discharges will dry last. When this wettest corn has dried down to 20 percent moisture, you may stop the fan and remove the covering from crib walls if the crib provides good ventilation. In such case the corn will continue to dry naturally to a safe storage moisture content. The moisture content can be measured by testing samples with a grain moisture tester such as used by local elevators.

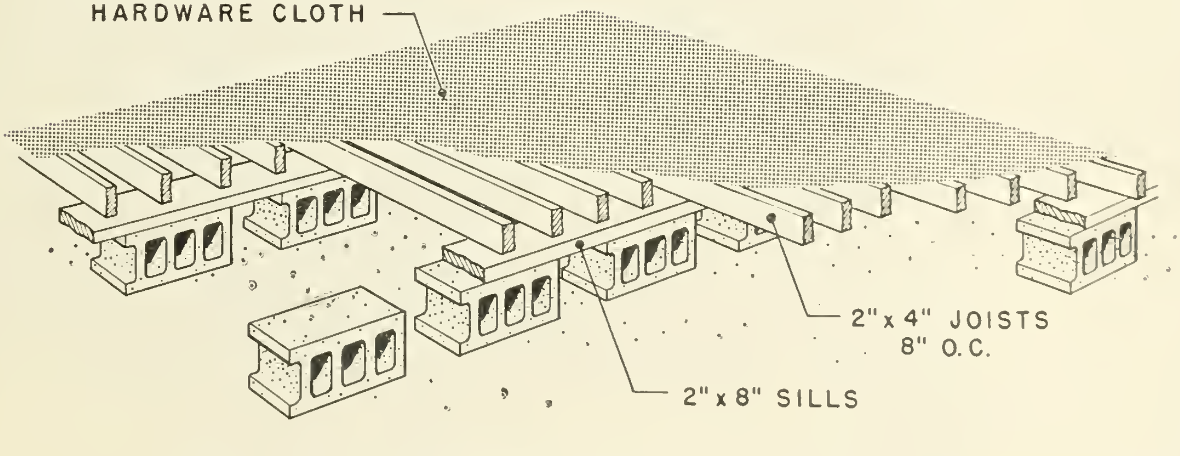


Figure 13.—*Details in use of hardware cloth as a false floor in a bin.*

If you dry ear corn in a bin with tight walls or in a crib with inadequate natural ventilation, run the fan in the fall until the wettest corn is down to around 18 percent moisture or until the corn is frozen. Forced ventilation in winter usually will not pay. If the corn is to be stored through the spring and summer, additional mechanical ventilation will be needed as the weather warms up in the spring.

If mechanical ventilation is to be used to dry ear corn down to 13 percent moisture for shelling and storage, usually the last of this ventilation will have to be done in April and May. At this time, and for this purpose, it is best to ventilate only on warm, dry days, rather than continuously.

If the weather is especially humid after corn is harvested, the corn may not dry enough in the fall for safe crib storage. In this case, run the fan until the corn is frozen. It will not pay to operate the fan further during the winter except to keep the corn frozen. Drying can be completed by additional mechanical ventilation as the weather warms up in the spring. This will add to the cost of drying, but, unless the weather is unusually humid in early spring, there should not be any serious damage to the corn. It should be recognized, however, that this method of drying does not completely eliminate the weather hazard in curing corn.

Cost

At an airflow rate of 5 c. f. m. per bushel, a minimum cost for electric power of about 2 cents per bushel is what can be expected for drying corn from a moisture content of 30 percent down to a point where the wettest corn in the crib will be at 20 percent moisture. There also will be overhead cost of equipment—that is, interest, taxes, and depreciation charges—and a small annual cost for covering the crib wall with paper or canvas, if corn is dried in a crib. The total cost for drying ear corn with unheated air may amount to 5 or 6 cents per bushel, assuming 1952 costs.

Weight Loss Caused by Moisture Reduction

Table 2 shows the weight of water in a bushel of ear corn at different percentages of moisture in the kernels. From these figures you can calculate the pounds of water that must be evaporated to dry ear corn from any initial moisture to any final moisture given in the table. Subtract the weight of water per bushel after drying from the weight of water per bushel at the start of drying. This information can be useful in deciding whether to sell damp corn and take a price discount for the high moisture content or to dry it and avoid the discount but have less weight to sell.

TABLE 2.—*Approximate amount of water in ear corn when harvested. at different percentages of moisture content of the kernels*

Kernel moisture content (percent)	Amount of water in a bushel of ear corn [1]		
	In kernels	In cobs	Total
	Pounds	*Pounds*	*Pounds*
35	25. 5	12. 4	37. 9
30	20. 3	9. 9	30. 2
28	18. 4	8. 8	27. 2
26	16. 6	7. 8	24. 4
24	14. 9	6. 7	21. 6
22	13. 3	5. 5	18. 8
20	11. 8	4. 4	16. 2
18	10. 4	3. 2	13. 6
16	9. 0	2. 1	11. 1
14	7. 7	1. 4	9. 1
12	6. 5	0. 9	7. 4
10	5. 3	0. 5	5. 8

[1] A bushel of ear corn is defined here as the quantity that will yield 56 pounds of shelled corn at 15.5 percent moisture.

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